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Sticky Information and Heterogeneous Needs as Determining Factors of R&D Cooperation with Customers

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Abstract

The aim of this work is to investigate the factors determining cooperation in developing innovations between firms and a specific group of agents, customers and users. The central point of the analysis is two variables recognised in previous studies as important factors in the study of cooperation with these agents, but which basically have been dealt with from a purely theoretical viewpoint. These variables are: 1) the existence of *sticky* information (information which is costly to obtain, transfer and use) and 2) the presence of heterogeneous needs in the market. Regarding the first variable, we have also taken into account two kinds of information which can be *sticky*: information on needs and information of technological nature. The findings obtained, using a Spanish sample of firms, show clearly that all these three factors exert a positive influence on cooperative relationships with these agents.

Keywords: R&D cooperation with customers, *sticky* information, heterogeneous needs, Spain.

1. Introduction

Cooperation in R&D between firms and institutions, as well as between the former and other economic agents has acquired ever-growing importance in the literature on innovation throughout recent years as a result of the growing complexity, costs and risks that innovation entails (Coombs et al., 1996; Hagedoorn, 2002; Nooteboom, 1999). Thanks to this cooperation, access was gained to resources and information that in many cases the firm itself is not able to generate internally (Becker and Dietz, 2004).

Moreover, the boundaries of both firm and knowledge are now fuzzier, which leads to the need to mobilise not only the firm's own staff and resources, but also external stakeholders of a highly diverse kind (Bonaccorsi and Lipparini, 1994). All this has meant that, at the present time, few firms are capable of launching the development of new products or processes by themselves (Tether, 2002).

In this way, in addition to the use of internal sources of innovation, firms use ideas stemming from outside, the origins of which may be very different (Arora and Gambardella, 1990; Gemünden et al., 1992; Knudsen, 2007; Powell et al., 1996; von Hippel, 1988, 2005). Thus, these innovation ideas may be provided by suppliers of materials and components, customers and users, universities or research institutions or even competing firms, each of whom has very different motives leading to their cooperation in each case.

This fact must be taken into account for a better understanding of the cooperation phenomenon, since to a great extent the selection of partners is non-trivial and requires careful attention as it may become a strategic decision. In any case, this choice will depend on the aims and strategies decided by the firm (Gemünden et al., 1992; Hagedoorn, 1990; Sorensen and Reve, 1998). Thus, the decision to engage in cooperative agreements with external partners should balance its advantages (e.g.: accessing new information, new opportunities or saving money and time) against the potential problems of losing information in an involuntary way

(Knudsen, 2007). In this line, there are some studies which try to guide firms in the selection of the most appropriate partner, if their objective is the design of a highly competitive product (Emden et al., 2006, Knudsen, 2007).

There are several authors who have researched into the determinants of cooperation in R&D (i.e. Belderbos et al., 2004a; Fritsch and Lucas, 2001; Kleinknecht and Reijnen, 1992; Tether, 2002) and recent studies have also given proof that the factors determining R&D cooperation may differ according to the type of partner (Belderbos et al., 2004a, 2004b; Cassiman and Veugelers, 2002; Fritsch and Lukas, 2001). Thus, bearing in mind the heterogeneity which surrounds the phenomenon of cooperation, the aim of the present work is to analyse the determining factors of collaboration in R&D with a specific group of agents, customers and users. Normally, this kind of collaboration has been jointly studied with supplier cooperation under the name of "vertical cooperation". There are ample references showing the importance of both types of vertical relationships for the development of innovative activity and knowledge creation for firms (Hauschildt, 1992; Teece, 1992; Tunisini and Zanfei, 1998). Nonetheless, it has been considered worthwhile to make a study of the concrete determinants of cooperation with customers without considering those which may jointly affect cooperation with suppliers, given that this distinction may facilitate the decision as to when it is advisable to cooperate with these partners.

On these lines, the main contribution of the study is to consider two variables which provide the boost for collaboration with customers. These had not previously, to our knowledge, received the attention they merit. They are: 1) the existence of *sticky* information and, 2) the heterogeneity of the needs of the market, thus offering a new viewpoint on this field of study.

In that sense, the major findings of this study can be summed up in two ideas. The first one is that *sticky* information exerts a positive influence on firms' propensity to cooperate with users. Furthermore, two kinds of information that can be *sticky* are analysed in this paper, information on needs and technological information, and in both cases this first idea is

corroborated. The second conclusion is that the presence of heterogeneous needs in the market also promotes cooperation with these agents.

Another distinctive characteristic of this paper is the use of a Spanish sample of firms to analyse the influence of these two variables on firms' propensity to cooperate with users because there are no previous studies that have carried out a similar analysis in this country. R&D collaboration, specifically with users, is an especially relevant issue for Spanish firms. Spain has to overcome a notably unfavourable situation as it is currently ranked near the bottom of the EU27 countries in terms of technological intensity and R&D cooperation. Results from the European Innovation Scoreboard 2007 (EIS 2007)[1] show that Spain is a moderate innovator country according to the Summary Innovation Index (SII)[2]. On the other hand, the 4th Community Innovation Survey (CIS 4)[3] demonstrates that, with reference to innovation activity, Spain is ranked (35% of firms with innovation activity) below the average of the EU27 countries (42%). According to innovation cooperation[4], Spain (18%) is also ranked below the average of the European countries (26%). Moreover, for the Spanish case, cooperation with customers in innovation activities presents the lowest rate of the European countries (4% of

1 The EIS (European Innovation Scoreboard) is the instrument developed at the initiative of the European Commission, under the Lisbon Strategy, to provide a comparative assessment of the innovation performance of EU Member States. The EIS 2007 includes innovation indicators and trend analyses for the EU27 Member States as well as for Croatia, Turkey, Iceland, Norway, Switzerland, Japan, the US, Australia, Canada and Israel.

2 The overall innovation performance is calculated on the basis of 25 indicators covering the five dimensions of innovation: innovation drivers, knowledge creation, innovation and entrepreneurship, applications measures and intellectual property. Based on their innovation performance, the countries included in the EIS 2007 fall into four groups: innovation leaders, innovation followers, moderate innovators and catching-up countries.

3 The Fourth Community Innovation Survey (CIS 4) conducted in every EU member state collects data on innovation activities in firms, namely on product innovation (goods or services) and process innovation. The CIS4 is based on the Eurostat/OECD Oslo Manual 1997. The CIS 4 produces a broad set of indicators on innovation activities, innovation expenditure, effects of innovation, public funding, innovation co-operation, sources of information for innovation, main obstacles in innovation activity and protection methods of intellectual property rights. The Community Innovation Surveys (CIS) are a series of surveys executed by national statistical offices throughout the European Union since 1992. The harmonized surveys are designed to give information on the innovative activities of different sectors and regions. The CIS 4 took place in 2004.

4 Innovation cooperation measures the active partnership of the observed firm with other firm or non-commercial institutions such as universities or public research institutes. Cooperation can take place with more than one partner.

innovative firms). Finally, results from CIS 4 highlight that Spanish firms prefer to collaborate with suppliers (9%), universities or other higher education institutes (5%) or with the government or public research institutes (5%) than with customers or users (4%). Anyway, in spite of the profile of Spanish firms, the results of this study are quite generally applicable to any country.

The work is structured in the following way. The second section records a brief review of the literature on cooperation with customers or users in the development of innovations. In the following section the hypotheses which we aim to test are described. The fourth section describes the characteristics of the sample used and the measurement of the variables. The descriptive analysis is presented in section five and the empirical findings of the statistical model are shown in the sixth section. Finally, the last section registers the discussion of the findings and the conclusions, along with the most important contributions of the study, its limitations and future lines of research.

2. Cooperation with customers or users

Traditionally, it has been assumed that generating and developing new products was the exclusive task of manufacturing firms. The mission of this manufacturing firm consisted of collecting information on market needs, for the subsequent development and commercialisation of a solution which would satisfactorily meet these needs (Foxall, 1989; Thomke and von Hippel, 2002; von Hippel, 1995, 2005).

In line with this approach, the customer or user only took part in the innovation process when he was required to and he was in no way considered the initiator of the process. To a certain extent he was passive. This idea gave rise to the *manufacturer-active paradigm*-MAP- (von Hippel, 1978a).

However, a series of works published from the seventies onwards (Herstatt and von Hippel, 1992; Rosenberg, 1976; Urban and von Hippel, 1988; von Hippel, 1977a, 1978a, b) clearly

showed that for a large number of industrial products this paradigm did not correspond to reality. From then on, attention was focused on the role played by the customer or user in the industrial innovation process. Thus the *customer-active paradigm* (CAP) emerged (von Hippel, 1978a).

In principle these two paradigms had different application contexts, albeit not entirely exclusive ones. The CAP turned out to be more suitable in industrial products, whereas the MAP was more fitted to generating ideas in consumer goods (von Hippel, 1978a, b).

Nonetheless, as time passed, the idea of the user-innovator promoted by the CAP has undergone a slight transformation. Although the early research into this phenomenon centred on innovations developed by customers and users (firms) in industrial goods (Enos, 1962; Franke and von Hippel, 2003; Freeman, 1968; Knight, 1963; Lüthje, 2004; Riggs and von Hippel, 1994; Shaw, 1985; Urban and von Hippel, 1988; VanderWerf, 1990; von Hippel, 1976, 1977a), at present a further step has been taken to include final customers and users in consumer goods areas (Franke and Shah, 2003; Lüthje, 2004; Lüthje et al., 2005; Shah, 2000). Users with similar interests and needs often form user-innovation communities, where members freely reveal their innovations and assist each other in innovation development (Franke and Shah, 2003; Hienerth, 2006; Tietz et al., 2005). It has even been demonstrated recently that, in some cases, user innovations are transformed into commercial products and many user-innovators decide to start companies in response to that demand. Then, user-manufacturers emerged showing several advantages in comparison with established manufacturers[5] (Baldwin et al., 2006).

In 1995, von Hippel gathered together these two behaviour patterns under the name of "*manufacturer-based design"* (figure 1) and *"user-based design" (*figure 2). At the same time, he mused about the need to have information referring both to technological needs and possible

[5] For instance, in terms of resources and capabilities, user-manufacturers have information with respect to user needs and desires, they may obtain free assistance from members of their communities and they can also take advantage of their low-capital cost production methods to enter profitably in a new market created by a "breakthrough" or when the expected interarrival time between successful designs is very short (Baldwing et al., 2006; Shah and Tripsas, 2004).

solutions for the development of new products and services, two types of information habitually to be found in different places.

Insert here figure 1 and 2

From this starting point, he designed a new innovation pattern known as *"iteractive user and manufacturer-based design"* (von Hippel, 1995), which consists of a combination of the previous two. In this case, solving the problem was achieved by means of various iterations between manufacturer and user so that the final product was the result of continuous trial and error processes. Thus, the successive prototypes proposed by the manufacturing firm were submitted to the user's evaluation until a minimally satisfactory design was obtained (figure 3).

Insert here figure 3

From the point of view of cost and efficiency it will be adequate that either the user or the manufacturer develops the design, when all the necessary information is localised in one of the two sites and it is difficult and costly to obtain (henceforth this will be called "*sticky information*"). However, when the information in the hands of the two agents is *sticky* and/or the learning takes place in two sites, collaboration between user and manufacturer will be more advisable. Even so, it would be recommendable to prevent this situation being reproduced in all projects, since working in this way requires continuous iterations between both agents (Shaw, 1985), it is costly and leads to marked delays in the process (Thomke and von Hippel, 2002). A solution in these cases would be to redefine the design tasks by dividing them into sub-problems, so that each of them requires access to just one agent –user or manufacturer- (von Hippel, 1995, 2002).

In any case, the fact that the customer or user enters as a participant in the innovation process changes considerably some of the functions developed in the heart of the firm. Specifically, functions assigned to R&D and marketing departments, such as new product design and development, could need, to a certain extent, to change to being carried out by external agents

(Thomke and von Hippel, 2002; von Hippel, 2005). This reality has meant for many firms having to give up certain tasks of the innovation process. In many cases this can be seen as a threat, particularly when these activities are critical or the source of competitive advantage (Thomke and von Hippel, 2002). For this reason it is important that the management function should be able to adapt the organisation to the new circumstances, by incorporating new technologies both in the case of communication and organisation (Jeppesen, 2002).

Regardless of the adjustments which should be made to tackle these changes, manufacturing firms obtain several advantages from this collaboration. In this sense, a better connection with the innovation process may be achieved and/or better results in commercialised products (von Hippel, 2005). The same may apply to the extension of the product or process life cycle which is being developed (Conway, 1993; Jeppesen, 2002), the improvement of the resulting product's commercial attractiveness or the development of the innovative process in a more directed manner in less time and at lower cost, etc. (Henkel and von Hippel, 2004; Herstatt and von Hippel, 1992; Jeppesen, 2002, 2005; von Hippel, 2005). Moreover, it makes it easier to establish an optimal relationship between the product's price and its attributes and helps to identify the most important characteristics that the product should have (Conway, 1993). In parallel fashion, the customer or user acquires certain information on how to use the product, and this enables him to use it more effectively and, at the same time, to serve as an example for potential customers. This speeds up the time needed for new designs to be accepted (Conway, 1993).

But not only are there advantages at firm level, the economy as a whole derives benefit from this relationship. It has been shown that social welfare is increased with a greater diversity of products on the market, so a larger number of customers or users can be satisfied (Harhoff et al., 2003; Henkel and von Hippel, 2004). What is more, since there are contributions from different actors with complementary abilities and knowhow, it is possible to design innovations beyond the capacity of one agent's ability to conceive.

However, collaboration with customers is not devoid of snags for manufacturing firms. For example, it is relevant to validate information provided by customers, to take into account that this relationship is not necessarily cordial or simple and that in products of a strategic nature both are running significant financial risks (Conway, 1993).

Once the advantages and disadvantages of putting this strategy into practice are known by the firm, it is worth their while to find out what are the conditions under which choosing to cooperate with customers will be the right thing to do. For that purpose, it is convenient to know what factors influence this decision, a question that has previously been dealt with in some studies (Bönte and Keilbach, 2005; Cassiman and Veugelers, 2002; Tether, 2002). However, the previous literature has not paid enough attention to two variables which may be important determinants of this kind of cooperation and which have a connection with: 1) the existence of *sticky* information and, 2) the presence of heterogeneous needs in the markets, the study of which constitutes the central point of this work.

3. ***Sticky*** **information and heterogeneity of needs**

There are several authors who have researched into the determinants of cooperation in R&D (i.e. Belderbos et al., 2004a; Fritsch and Lucas, 2001; Kleinknecht and Reijnen, 1992; Tether, 2002). In a general way, the literature identifies three categories of factors which promote this cooperation (among other studies: Cohen and Levinthal, 1989; Sakakibara, 1997; Tyler and Steensma, 1995): 1) questions related to the fact of cost and risk-sharing, 2) motives to do with the search for complementarities among partners and 3) factors related to the absorptive capacity of the firm.

However, recent studies have given proof that the factors determining R&D cooperation may differ according to the type of partner (Belderbos et al., 2004a, 2004b; Cassiman and Veugelers, 2002; Fritsch and Lukas, 2001). For example, it has been shown that the existence of permanent R&D activities promotes cooperation with customers, competitors or consultancies, whereas in cooperation with suppliers and universities differences show up with regard to the level of

expenditure on R&D activities, more than if the R&D is performed continually or occasionally (Tether, 2002). In the case of firm size, this variable turns out to be highly influential in cases of cooperation with suppliers and universities but, on the other hand, counts for little in cooperation with competitors and consultancies and is particularly weak in the case of customers (Tether, 2002). Other examples are found in Cassiman and Veugelers (2002), who reached the conclusion that having effective methods to protect innovations influences cooperation with suppliers and customers, but not cooperation with research institutes, or in Mohnen and Hoareau (2003), who observed that the size of the firm, government support, patents and the scientific status of the industry were indeed factors contributing positively to explaining cooperation with universities compared to other types of cooperation.

For all of the above reasons and bearing in mind the heterogeneity and uncertainty which surround the phenomenon of cooperation, especially in the case of cooperation with users, in this paper we analyse the effect of two variables that have been scarcely considered in previous works. They are: 1) the existence of *sticky* information (von Hippel, 1994, 1998, 2001, 2002; von Hippel and Katz, 2002) and, 2) the presence of heterogeneous needs in the market (Franke and von Hippel, 2003; Jeppesen, 2005; Lüthje and Herstatt, 2004; Ogawa y Piller, 2006; von Hippel, 2005; von Hippel and Katz, 2002).

3.1 *Sticky* information

Several empirical works have made it clear that the information necessary for developing innovative projects can offer different degrees of difficulty and cost when transferred, especially in the case of technological information (Pavitt, 1987; Rosenberg, 1982; Teece, 1977).

Thus, when the required information can be transferred at no cost, this will have no effect on the place where the problem-solving activities take place. On the other hand, when it is expensive to acquire, transfer and use that information it is said to be "*sticky*" (von Hippel, 1994, 1998, 2001, 2002; von Hippel and Katz, 2002) and in those cases it is worth taking into account what may be the most suitable place to solve the problem.

The first investigation which gave rise to the analysis on difficulties in allocating economic resources to information-intensive goods was developed by Arrow (1962). In this study, the author argued that information-intensive goods are the main result of innovation activities. These goods present characteristics similar to public goods: they are costly to produce and easy to transfer. However, this conception of innovation was subsequently abandoned in the literature, even in later works of this author (Arrow, 1994). In contrast, it has been argued that the cost of transferring technical information reflects how easy or difficult the transfer is (Teece, 1977) and several authors have suggested that much information of interest to problem-solvers and innovators is in fact costly to replicate and diffuse (Cohen y Levinthal, 1989, 1990; Nelson, 1982, Rosenberg, 1982; Teece, 1977, 1986).

Some years later, von Hippel (1994) introduced the concept of *"sticky"* information describing it as that information which is difficult to transfer. In a concise way "*the stickiness of a given unit of information in any given instance is defined as the incremental expenditure required to transfer that unit of information to a specified locus in a form usable by a given information seeker. When this cost is low, its stickiness is said to be low, when it is high its stickiness is high*" (von Hippel, 1994:430).

But despite the time that has elapsed since these early works on *sticky* information it is true that there is practically no empirical evidence on how to measure this variable, as will be seen in the section dealing with measurements.

What is more, there are many reasons why the information may show this characteristic. Those most often mentioned in the literature are related to three questions. The first refers to the nature and characteristics of the information itself, and may be the form in which it is encoded or its tacit character (Nelson, 1982; Nonaka and Takeuchi, 1995; Pavitt, 1987; Szulanski, 1996; Rosenberg, 1982; von Hippel, 1994, 1995). Secondly, it is also mentioned that the cost of transferring information will vary according to the structure and amount of information required (Rosenberg, 1976; von Hippel, 1995), since a large amount of information is requested because

ones does not know in advance which subset of that information will be relevant and which will not (von Hippel, 1994). The third and final reason is concerned with the attributes of the seekers and providers of the information (Szulanski, 1996; von Hippel, 1994; von Hippel and Katz, 2002). For example, the utility which a certain unit of information may have varies according to the previous knowledge which the person who is going to use it has, or to put it another way, it will depend on the absorptive capacity of new knowledge that the receiver possesses (Cohen and Levinthal, 1989, 1990; Pavitt, 1987).

However, it is also worth pointing out that it is possible to reduce the costs of transferring *sticky* information by following one of the four paths (von Hippel, 1994). First, when the *sticky* information required is presented in just one place, the activities for solving the problem or developing the innovation will transfer to that point. Second, if the necessary *sticky* information is presented in several places, then iteration will be needed among these locations as the development work advances. Third, when these iterations turn out to be costly, the innovation activities requiring access to *sticky* information found in many points will be divided into sub-tasks on the basis of who possesses this information. Finally, it may be viable to make investments to reduce the degree of *stickiness* of the information. An example of this latter case would be to seek the way to convert the tacit knowledge of an expert into explicit knowledge which is less difficult to transfer.

Nevertheless there must be incentives to motivate investment effort to reduce the *stickiness* of a unit of information. Those incentives vary depending upon how many times that unit is expected to be transferred, which may also affect where innovation will take place -user *versus* manufacturer- (von Hippel, 1998). Normally, manufacturers tend to specialise in a particular type of solution and try to apply it to different problems raised by users. That is, the information required from the manufacturer is usually the same for dealing with several users, whereas the information required from the user is usually unique and only necessary for a specific use. Thus, normally the investment takes place to make it easier to transfer information from the

manufacturer to the user, rather than the opposite and it is at the site of the latter, where the less required information is found, that the work takes place to solve the problem (von Hippel, 1994).

Thus, it must be borne in mind that normally, in order to solve a problem related to developing an innovation it is necessary to bring together different types of information which, at least a priori, are usually physically located in different places (von Hippel, 1994). This gives rise to the existence of certain information asymmetries between customer or user and the manufacturing firm (Thomke and von Hippel, 2002).

On the one hand, there is the information referring to the need which is to be met and the context in which the products and services are to be used, on the other hand, the most suitable technical information to provide solutions for these necessities are found (von Hippel, 1994, 1995, 1998). Generally, the customer or user is ready for the former type of information, whereas the manufacturing firm usually takes advantage of the latter.

Both types of information can show high levels of *stickiness*, which makes it worthwhile to find ways of acting that avoid their transfer from one place to another when this situation arises.

A suitable answer in these circumstances is that the manufacturing firm chooses to delegate certain tasks of the innovation process to its customers. This enables it to save on certain costs and avoids another series of extra difficulties (von Hippel, 1994; 1995, 1998). For this purpose all that is needed is to divide the tasks associated with innovation development into sub-problems that each draw on only one such locus of *sticky* information. Subsequently, these sub-tasks will be allotted in the most suitable way to whomsoever has the *sticky* information needed to carry it out (manufacturing firm or customer). Thanks to this cooperation each activity will manage to be performed in the specific place where the *sticky* information is found, without the need to transfer it (von Hippel, 1994, 1995, 2001; von Hippel and Katz, 2002). Nevertheless, it must also be borne in mind that task partitioning can be done in several ways, and this would

determine to a great extent the amount of information which would be needed in each case, how efficiently each task is developed and the results of the project (von Hippel, 1990).

Taking into account all of the above, and without forgetting that there are several alternatives, the hypothesis that we aim to test is that:

H1: The need for sticky information for the development of innovations has a positive influence on the likelihood of the firm cooperating with customers or users.

In order to go more deeply into this aspect and bearing in mind the two types of information that can be presented by this characteristic, it is worthwhile posing two sub-hypotheses. The first rests on the fact that if the firm finds it difficult to identify its customers' needs it is worth cooperating with them in developing innovations and, therefore:

H1a: If information on needs is sticky, the manufacturing firm will be more likely to cooperate with its customers or users in order to develop innovations.

The second refers to information of a technological nature. If an innovation requires specialised information for designing and making, such information will be complicated to transfer to the customer for he/she to solve the technological problems faced by himself or herself. This leads us to pose that:

H1b: If the information regarding problem solution is sticky, the manufacturing firm will be more likely to cooperate with customers or users for innovation development.

3.2 Heterogeneity of needs

Along with the existence *of sticky* information, the taking advantage of users in the innovation process is seen to be motivated by the presence of heterogeneous needs in the market, which is quite normal at the present time. In this sense, von Hippel (1998) recommended putting part of the problem solving work in the hands of the product or service user when the manufacturer is facing heterogeneous demand.

The “heterogeneity of need” in a group can be defined as the degree to which the needs of *i* individuals can be satisfied with *j* standard products which optimally meet the needs of those individuals. When many standard products are required to meet individuals’ needs, the heterogeneity will be high. On the contrary, heterogeneity is said to be low or demands are homogeneous when the number of standard products needed is small (von Hippel, 2005:39).

The trend towards increasingly more heterogeneous needs among consumers in important markets has led to the development of new products becoming a really difficult, complex process (von Hippel, 2001). The tasks of designing, producing and commercializing the product are sometimes very costly for the manufacturing firm, so it is only economically worthwhile to satisfy those market segments where such expenditures can be spread among a broad group of customers (Franke and von Hippel, 2003; Jeppesen, 2005; Lüthje and Herstatt, 2004; von Hippel, 2005).

These market segments are characterised because inside them the needs of the vast majority of their members are similar and therefore they can be met with standard products. Following this reasoning, a very important part of the market is left unsatisfied since it is not economically attractive from the viewpoint of the manufacturing firm (Franke and von Hippel, 2003).

Consequently, when products currently offered by the firm are not suitable to meet the demand of customers or users with heterogeneous needs, the firm has two possible alternatives. The one most commonly followed is that of segmenting markets, even attending to “markets of one” (Franke and von Hippel, 2003). However, although mass customization has eased the way to meeting heterogeneous demands and needs, in many industries it is not the best solution (Zipkin, 2001). The other option put forward consists of supporting the customers or users so that they themselves take the initiative in improving or developing the products that may satisfy their heterogeneous tastes (Lüthje and Herstatt, 2004, Ogawa and Piller, 2006). In this way the manufacturing firm instead of struggling to understand the needs of its customers and users, can equip them with certain tools to facilitate tasks in designing products in accordance with their

concrete needs and collaborate with them in the process of developing a new product or process (Franke and von Hippel, 2003). But, just as in the previous case, this option may come up against certain limitations when they are put into practice (Franke and von Hippel, 2003; von Hippel and Katz, 2002).

In any case, there is evidence that heterogeneity of market needs has a positive influence on the setting up of cooperative relationships with users (Franke and von Hippel, 2003; Jeppesen, 2005; Lüthje and Herstatt, 2004; von Hippel, 2005; von Hippel and Katz, 2002; Ogawa and Piller, 2006) and therefore the hypothesis to be tested is:

H2: The greater the heterogeneity in market needs, the greater will be the need to cooperate with customers or users for the development of innovations.

By way of a summary of all the above, it can be said that customer or user involvement is determined to a large extent by those two variables, since the cost of designing a satisfactory product will be increased due to the presence of either of them (Jeppesen and Molin, 2003).

4. Methodology

4.1 Sample

The source of the data used in carrying out the empirical study has been the Spanish Business Strategies Survey (*SBSS*) drawn up by the Public Enterprise Foundation (Fundación Empresa Pública –*FUNEP*-). It is one of the most important statistical sources for studying innovation in Spanish industry and in fact, previous research in the field of innovation has used this same source for studying, for example, the design of firms' technological strategy (Beneito, 2003) or cooperation for the development of innovative products (Nieto and Santamaría, 2006). It has been prepared every year since 1990 and in the part devoted to quantifying firms' innovative activities provides information about technological activities and R&D expenditures from a live sample of Spanish firms, the number of which is about 1800 annual observations.

One of their main advantages is offering information at firm level, which enables it to be the sample unit of this study.

The sample is representative of the population of Spanish manufacturing firms; it is random and stratified according to firm size (in terms of the number of employees) and industry sector. The reference population is firms with 10 employees or more in Spanish manufacturing industry with data available from 1990 till 2002. From 1998 onward, the variables referring to technological cooperation with several partners, among them customers, were introduced. Due to a large number of questions in the questionnaire being not very different as far as time is concerned, the complete questionnaire is only prepared every four years. Thus the most recent four-year survey is the SBSS-2002 on, so this has been the year considered for carrying out the present study.

From a total of firms forming part of the ESEE sample, those who claim to have cooperated with customers throughout 2002, and those who have not, are identified. As a result a sample of 1,533 firms has been obtained[6], of which 291 (18.98%) claimed to have had technological collaboration with customers. Following on from Fritch and Lukas (2001) and Motti and Sachwald (2003), firms have been included which replied to the survey without a distinction being made between those that have innovated and those which have not. This distinction could lead to skewed results, as has been recognised in previous studies on innovatory behaviour in innovating firms (Bayona et al., 2001; 2003; Cassiman and Veugelers, 2002; Nieto and Santamaría, 2006; Tether, 2002).

4.2 Selection of variables

4.2.1 Dependent variable

The empirical literature extensively resorts to the number of agreements (i.e. an "absolute" variable) as a proxy variable of the propensity of a firm to collaborate (Colombo and Garrone,

[6] The sample of firms chosen is representative of the whole of the population of firms.

1996). Berg et al. (1982) measured it using the average number of agreements in the cross-industry models, as do Arora and Gambardella (1990, 1994). The firms´ propensity towards cooperation can also be measured using a "relative" variable such as the ratio of the number of agreements to R&D expenses or to firm sales (Colombo and Garrone, 1996). The dependent variable which is the object of our study is dichotomous, **cooperation with customers,** and represents the fact of collaborating or not with these partners to develop innovations. This variable takes the value 1 when the firm claims that there has been technological collaboration with customers and 0 if there has not been any cooperative relationship (Miotti and Sachwald, 2003; Nieto and Santamaría, 2006).

4.2.2 Explanatory variables

The most outstanding works in the field of innovation which have considered the existence of *sticky* information as a key element in developing new products have not used any exact measure of this variable due to its complex and ambiguous nature (Ogawa, 1998; von Hippel, 1994, 1998; von Hippel and Tyre, 1995). Many of them are case studies that analyse the effect that can be produced by this variable in locating innovation activities and the possible solutions which can be used when it occurs (Jeppesen, 2005; Morrison et al., 2000; Shah, 2000; von Hippel, 1994, 1998, 2001). Therefore, few references have been found in which a measurement is made, and moreover, they always use proxy variables of the *stickiness* of the information (Ogawa, 1998; Szulanski, 1996).

Szulanski (1996) analysed how firms can transfer their best practices (information and knowhow) within the organisation itself. For this purpose, he considered that such a transfer is a progressive process which he divided into four stages: initiation, implementation, putting into practice and integration. From this point, he analysed the degree of *stickiness* in the transmission of that information for each of the four phases, getting close to the measurement of this variable by means of drawing up several multi-item scales in an ad-hoc questionnaire.

In our study the hypotheses posed are more in the line of those which were tested in their time by Ogawa (1998), since he also took into account the existence of two types of information: information on needs and technological information. In his study the author considered that, along with the expected benefit, the presence of *sticky* information is a factor which determines the place where an innovation is going to be developed. Just as in the previous case, the author recognises the difficulty of directly measuring this variable and chooses to use two proxy variables: 1) the number of activities developed by the user which were novel to the manufacturer (degree of *stickiness* of the information on needs) and 2) the number of component technologies incorporated in an innovation that were novel to the user (degree of *stickiness* of technological information).

Following an approach similar to the latter, *sticky* information referring both to needs and to problem solving has been measured by using two proxy variables in each case.

In the first case, **information on needs**, it is logical to think that if the market needs are difficult to identify and even the customers and users themselves find it difficult to recognise them, this information will be *sticky* and it will be difficult to obtain through market research methods. Thus, if the firm had carried out or contracted market research for the launch of new products, information about needs will not be *sticky*, because it would be quite easy to acquire. We have defined a variable that varies from 0 to 5 considering the number of years that the firm has carried out or contracted market research for the launch of new products[7]. So, the more years the firm have used market research methods, the less *sticky* will be the information about needs. The second variable used to measure the *stickiness* of information about needs is related to how often the firm changes its products. It is supposed that if the firm changes its products very often, it can be due to the lack of accurate information on market needs, because that information is difficult or costly to acquire, in other words, it is *sticky*. In this case, the variable

[7] The survey used provides information about this variable since the year 1998, so the maximum number of years that the firm could have carried out or contracted market research is five.

takes the value 1 if the firm usually changes its products, this information is *sticky*, and value 0 in the opposite case.

Regarding the second case, **technological information**, it has been observed that the fact of having specialised staff may affect the cost of transferring a unit of information between firms (Szulanski, 1996; Ogawa, 1998). That variable could be considered as an indicator of *stickiness* of the information concerning problem solving, since a high level of staff training in R&D will imply that a great deal of knowhow is needed to design and make the new products technically. This will make it more complicated to transfer this information to the user. This is the first measure considered and it deals with the percentage represented by the staff with higher education qualifications in the R&D department as a percentage of the total number of staff in that department, since the higher the level of training required, the greater will be the degree of *stickiness* of technical information which these workers will have to handle. We have also considered that technological information could be *sticky* if the firm has had to use external experts or consultants to obtain information about new technologies. So, we used a dichotomous variable that takes value 1 if the firm has used experts and/or consultants to learn about new technologies and 0 in other cases.

As far as **heterogeneity of market needs** is concerned, throughout the literature reviewed on innovation development, only one work has been found in which a measurement of it is made. In this study, carried out by Franke and von Hippel (2003) the authors drew up a "heterogeneity coefficient" to measure this variable in the case of a specific product, Apache security software. This coefficient was calculated by considering the distances among 45 software dimensions and the needs of two user groups of this product. For this coefficient to be comparable in different groups, they calibrated it by averaging the heterogeneity of many random distributions of heterogeneity of the same kind. Thus, when the results of the quotient between the empirical coefficient and the average random heterogeneity coefficient were higher than 1, it indicated that there was a tendency to dispersion and, thus, the heterogeneity was high. On the contrary,

when the quotient was less than 1, it indicated that there was a certain tendency to form clusters or groups with similar needs. If the result equalled 0, it meant that needs of all the individuals were the same, and, therefore, there was no heterogeneity.

In our case, given that it was impossible to construct an indicator with similar characteristics to the above-mentioned one, due to the type of data supplied by the SBSS, this factor has been measured by using a dichotomous variable, which clearly reflects the phenomenon studied. For this purpose, the replies to the question on the existence of differentiation in the firm's products have been considered. Thus, the variable takes the value 1 when most of the products manufactured by the firm have been designed specifically for each customer (high heterogeneity) and the value 0 when products are highly standardised and are the same for all buyers (low heterogeneity).

4.2.3 Control variables

We also have considered some classic variables that have been found to relate to the nature and pattern of innovative and cooperative activity and which, in our case, are used as control variables. So, we have included some controls for firm-specific characteristics –R&D experience, openness to the cooperation strategy, foreign capital, size- and controls for industry characteristics –the technological intensity of the sector-.

It must be borne in mind that for the information provided by external agents to be effectively used by the firm, the latter needs to have a certain knowledge basis which may make it easier to assimilate (Cohen and Levintal, 1989, 1990). This fact impinges on firms' decisions to cooperate with different agents, among them with customers (Bönte and Keilbach, 2005; Fritsch and Lukas, 2001; Tether, 2002). In this sense it has been shown that carrying out R&D activities in a continuous way increases the propensity to collaborate with external agents, among others, with customers (Tether, 2002). For this reason, ***previous experience in R&D activities*** has been taken into account, measured by means of a dummy variable which will take

the value 1 if the firm carried out R&D activities internally in the previous period, 2001, and value 0 if they did not do so[8].

In centring the analysis on a very concrete type of cooperation, it is convenient to take into account the firm's openness to the cooperation strategy and how the collaboration with other partners in innovation may influence this decision (Belderbos et al., 2004a; Fontana et al., 2006; Laursen and Salter, 2004). To express this topic in the study we prepared the variable ***openness to cooperation*** that indicates the number of external agents the firm has cooperated with during the previous period[9] (values from 0 to 5), since it is to be expected that the more open its cooperation strategy is; the greater will be the propensity to collaborate with customers[10].

Another variable considered quite often is the ownership structure of the firm. There are studies that confirm the idea that foreign firms seek collaboration with domestic customers to learn more about the requirements of the local market (Tether, 2002) and in these cases, there exists a certain tendency to collaborate vertically, as well as with universities and research centres (Belderbos et al., 2004a). Therefore, the fact that a part or the whole of the firm's capital is in foreign hands may affect the likelihood of cooperation from the latter. In this way, the variable ***foreign capital*** has been measured as the percentage that represents the foreign capital in the ownership of the firm.

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[8] When this variable was built, it was taken into account that in the questionnaire the firm was asked to indicate whether they carried out or contracted R&D activities in the corresponding year and therefore in the replies all possible options with regard to those two alternatives are recorded. For example, it neither carried out R&D nor contracted it, it did so internally but with no outside contracts, etc. For our study we are only interested in finding out whether R&D was performed internally, regardless of the fact that at the same time there was external contracting or not.

[9] The five external agents considered to design this variable are: universities and/or technological centres, suppliers, customers or users, competitors and participation in technological cooperation agreements or joint ventures.

[10] Like Laursen and Salter (2004: 1204), we assume that the higher the number of external information sources that a firm uses in its innovation activities; the more "open" it is.

At present there is no consensus regarding the effect that ***size*** may have on the likelihood of a firm collaborating with external agents[11]. Whereas some authors find no relationship whatsoever between firm size and cooperation (Arora and Gambardella, 1990; Kleinknecht and Reijnen, 1992; Pisano, 1990; Robertson and Gatignon, 1998), others support the existence of a positive relationship between those variables (Bayona et al., 2001; Cassiman and Veugelers, 1998, 2002; Colombo and Garrone, 1998; Fritsch and Lukas, 2001; Hagedoorn and Schakenraad, 1994). An even higher propensity towards cooperation has been observed in smaller innovative firms in comparison with larger ones (Veugelers, 1997). In this way, for the case of cooperation with customers or users, the direction of the relationship is also shown as uncertain. To measure size, three dummy variables have been created reflecting the categories of *small* (fewer than 50 employees), *medium-sized* (from 50 to 250 employees) *and large firm*[12] (250 or more employees).

As far as the industrial sector is concerned, we have designed three dichotomous variables regarding the ***R&D intensity of the industry***: *high-tech, mid-tech* and *low-tech*, which take value 1 when the firm belongs to that category of sector and 0 in the opposite case. This variable has been considered because numerous studies show that the fact of belonging to a high-tech intensity sector increases the likelihood of taking on cooperation agreements in general[13] (Bayona et al., 2001; García Canal, 1995; Hagedoorn, 1993; Miotti and Sachwald,

[11] It may be thought that smaller-sized firms, due to their lack of internal resources, could find themselves forced, more than large firms, to seek forms of cooperation which would enable them to internalize the information and skills needed to be able to carry out certain innovative projects, projects which otherwise would be out of their reach (McPherson, 1997; Oliver and Blakeborough, 1998). Nevertheless, the type of information that is normally sought in these cases tends to be highly complex. This fact obliges the firm to have a base of previous knowledge that might allow it to absorb new knowledge. To achieve this, they would previously have had to make important internal efforts in research activity (Cohen and Levinthal, 1989, 1990). To attain this state is much more feasible for large-sized firms (Cohen, 1996), and means that sometimes small firms cannot choose to cooperate through lack of previous knowledge.

[12] This classification by sizes has been made taking into account the recommendation of the European Commission "Commission recommendation of 6 May, 2003, concerning the definition of micro, small and medium-sized enterprises" (notified under document number C(2003)1422).

[13] In this line, Bayona et al. (2001) drew up a profile of Spanish manufacturing firms cooperating in R&D and among their characteristic traits was that of belonging to high-tech sectors.

2003; Robertson and Gatignon; 1998; Wang, 1994). This tendency has also been observed in the specific case of cooperation with customers, where medium and high-tech manufacturing firms are the ones most likely to collaborate with this type of partner (Tether, 2002).

5. Descriptive analysis

Table 1 presents a detailed analysis of the chosen sample of firms. In percentage terms, it can be pointed out that within the group of firms cooperating with customers the proportion of large firms is comparatively higher than that of smaller ones (57.04% for large ones against 29.21% for medium-sized ones and 13.75% in the case of small firms). Regarding the three sectoral categories used, the percentages for the group of firms which did not cooperate with customers was noticeably higher than for the group which did (in all three sectors), although this difference is less in the case of the high-tech sector.

Insert here table 1

In Table 2 some descriptive statistics are shown for the sample referring to the different variables chosen in the study. As has been previously indicated, of the total number of firms only 18.92% cooperated with customers.

Insert here table 2

The aim of the following table has been to discover whether there exist differences in the chosen variables to approach factors determining cooperation with customers for the development of innovation activities. The table presents the mean differences between the group of firms that have cooperated with customers and those that have not.

Insert here table 3

Except in the case of small-sized firms and the low-technology sector, the means of the group of firms which have cooperated with customers are higher than those who have not cooperated. Moreover, for all the variables significant differences are observed between both

groups. Therefore, these results show signs that the chosen variables could be important when explaining the propensity to collaborate with this type of partner.

6. Results

As has just been shown, the dependent variable used, cooperation with customers, is a dichotomous variable so it is necessary to choose a distribution function that can adequately represent the relationship between the explanatory variables and the probability that the firm will conduct co-operative R&D activities with customers. The *probit* and *logit* estimation models are suitable for contrasting the hypothesis in this type of cases (Aldrich and Nelson, 1984; Green, 2000; Liao, 1994). In this work, it was decided to use the *logit* model bearing in mind that from the theoretical viewpoint it is difficult to justify the choice of one model or another, whereas in practice very similar results are achieved by choosing one distribution or another (Greene, 1999).

In Table 4 the estimates of the impact of the explanatory variables on propensity to cooperate with customers are recorded. From the results it can be observed that the validity of the model is extremely high (Pseudo-R^2=0.5235). This statistic indicates that the variables included in the model explain a fairly high percentage, rather more than half, of the likelihood of cooperating with customers or users. Therefore, it can be said to be adequate for identifying the factors determining collaboration with those agents. In addition, the correctly predicted results of the model have been also included[14]. The percentages of correctly predicted zeroes and ones (92.94% and 77.91%, respectively) as well as the percentage of cases correctly predicted (90.41%) indicate an acceptable goodness of fit statistics.

Insert here table 4

[14] This means that we predict that a case is highly likely to fall into the category. If the Prob(X_i=1) ≥ Prob(X_i =0), then the predicted value of X_i equals one, while if Prob(X_i =0) > Prob(X_i =1), then we predict that X_i equals zero.

If the results for each of the hypotheses proposed are analysed individually, there is confirmation that the existence of *sticky* information has a significant influence on the decision to cooperate with customers (hypothesis H1), both on the side of needs and that of technological information. However, it is worth making a distinction between those two cases.

As far as the *stickiness* of the information referring to needs is concerned, the first measure used, market and marketing research, turns out to be significant and with a negative sign. Regarding the proposed hypothesis (H1a), this effect can be interpreted as in markets where information on needs is not *sticky* because it could be easily obtained using market research, so firms are less likely to cooperate with users. In other words, in contexts where there is no *sticky* information about needs, the firm can make use of different ways to help it to access such information instead of cooperation with users. The second measure, product change, exerts a positive and significant effect on firms' propensity to cooperate with users. This result indicates that if the firm does not have the accurate information to develop products that properly satisfy market needs, then it has to change its designs very often and it is more likely that the firm will cooperate with users in order to adapt its products better to market demands.

To the extent that technological information is concerned, the two variables considered have a significant and positive effect on firms' propensity to cooperate with users, so the hypothesis formulated (H1b) is confirmed. It can be said that the requirement for highly qualified staff in the R&D department as well as the use of external experts and consultants in new technologies, show that technological information could be complex and difficult to acquire. Hence, the design of new products or the solution to the technical problems of the actual ones requires specialised information that will be difficult and costly to transfer. Therefore, in these circumstances, the firm might consider it desirable to cooperate with customers or users in the joint development. In this way, there is no need to transfer the technological information to the customer, so he/she will not have to adapt the product to his/her needs.

Thus, these results are in line with the ideas proposed by other studies about the existence of information asymmetries between manufacturing firms and users (Thomke and von Hippel, 2002; von Hippel, 1994, 1995, 1998). When information is *sticky*, it is advisable for the user to participate in the innovation process (von Hippel, 1994, 1995, 1998, 2001; von Hippel and Katz, 2002). So, whatever the kind of *sticky* information considered, cooperation with users will be a correct solution.

The other important point in this study is the consideration of the heterogeneity of market needs as a determining factor of cooperation with customers or users. In view of the results, the hypothesis formulated (H2) is corroborated, since this variable has a positive and significant influence on firms' propensity to collaborate with this type of partner. These results empirically confirm the idea proposed in other previous studies (Franke and von Hippel, 2003; Jeppesen, 2005; Lüthje and Herstat, 2004; von Hippel, 2005; von Hippel and Katz; 2002). Thus, it can be affirmed that the more differentiated the products demanded by the market in which the firm operates, the more worthwhile it is to opt for a strategy of collaborating with customers. In this way, the firm avoids continuous processes of trial and error, which are costly and slow down the new product's launch on the market (von Hippel, 1994, 1995, 2005, Jeppesen and Molin, 2003).

As for the rest of the variables, previous R&D experience has shown there to be a positive, significant influence on the dependent variable, just as occurs with the variable "openness to cooperation". Specifically, this last variable presents the highest coefficient (0.089), and thus this is the main determinant of firms' propensity to cooperate with customers.

Just as had been foreseen, the fact that the firm may be foreign-owned has a positive, significant influence on propensity to cooperate with customers, thus reaffirming the idea that entering foreign markets promotes the search for collaboration relationships with those agents to adapt their products as well as possible to local demand.

With regard to the last two variables, neither size nor the sector turned out to be significant variables and therefore it cannot be concluded that they are determining factors in such collaboration, at least in the Spanish case.

7. Discussion and conclusions

The central aim of this study has been to make a more profound analysis of the factors determining R&D cooperation with a specific group of agents, customers and users, in a sample of Spanish firms. In that way, the Spanish case is relevant because results from the Community Innovation Survey and from the European Innovation Scoreboard indicate that Spain is in a notably unfavourable situation as it is currently ranked below the average of the EU27 countries in terms of innovation intensity and R&D collaboration. However, the results of this paper are generally applicable to the majority of firms in any country and they attempt to show how, in some circumstances, cooperation with users could be an advisable strategy for the development of innovations.

For that purpose, a series of variables commonly used in other studies on cooperation with external agents has been used, such as R&D experience, openness to cooperation, percentage of the firm's capital in foreign hands, size and sectoral R&D intensity. However, the main contribution of this work is related to the inclusion, as has been suggested by some previous researches (Ogawa, 1998; von Hippel, 1994, 1998), of two new variables which have been shown to play an important role in this question: 1) existence of *sticky* information and 2) heterogeneity in market needs, but these have been usually studied from a theoretical point of view.

As for the former, a distinction has been drawn between *sticky* information referring to needs and *sticky* information regarding technological information for problem solving. As has been done by other authors (Ogawa, 1998; Szulanski, 1996), both have been measured by using proxy variables given the impossibility of measuring them directly.

Firstly, in the case of information on needs, the results indicate that in contexts where information is not difficult and costly to transfer (the firm uses market research methods continuously to obtain it), there is no necessity to cooperate with customers to access information on market needs. However, when information about market needs is *sticky* (the firm needs to change its products very frequently perhaps because of the difficulty of accessing market information), cooperation with users will be a good strategy. This conclusion has important implications. It must be borne in mind that by means of market studies it is possible to find out needs that the customer has already identified (information that is not *sticky*). However, in collaborating with customers, firms have the chance to access a type of information, which would otherwise be very difficult to obtain, and even in certain cases impossible. For example, cooperation with users allows the firm to take an extra step to find out many other needs the customer is not even aware of (Leonard and Rayport, 1997; von Hippel and Katz, 2002), and thus take advantage of this information to create a sustainable competitive advantage (Sheth and Sharma, 1997), because it would be very difficult for a competitor to be able to reproduce a similar relationship. In these cases, the firm can choose among a range of solutions to integrate users into the innovation process, depending on the level of customer interaction desired. For instance, postponement, mass customization or collective customer commitment (Ogawa and Piller, 2006), can be valuable alternatives to obtain accurate information about market needs when this is *sticky*.

Secondly, with reference to *sticky* information of a technological nature, the hypothesis posed is also confirmed. This means that when the development of an innovation requires information which is specialised and difficult to transfer, it is convenient to collaborate with the customer or user. Working jointly with him in solving technical problems that may arise avoids having to transfer this information to him, so he will not have to solve technological problems once the product is in his hands. Due to this learning, the firm avoids wasting time and effort in solving that kind of problem. Even more, thanks to this cooperation, the user could contribute

with more valuable ideas for the development of new products but, he could even acquire some technical information (Hienerth et. al. 2007; Lüthje et. al., 2005) that will be very useful to develop new processes (von Hippel, 1977b), new technologies (Lettl et. al., 2006) or more radical innovations (Lynn et. al. 1996; Lüthje and Herstatt, 2004; Veryzer, 1998).

Regarding the heterogeneity of needs, the main contribution to the literature is to be the first, to attempt to test empirically the effects of this variable on firms' propensity to cooperate with users. The results of the research support the hypothesis that a high degree of differentiation in the products demanded by the market has a positive, significant effect on the propensity to cooperate with customers in the development of innovations for Spanish firms, in the same line as theoretically proposed in other preceding studies (Jeppesen, 2005; Lüthje and Herstat, 2004; von Hippel, 2005; von Hippel and Katz, 2002). This fact makes sense to the extent that if the firm faces among its customers very heterogeneous needs and tastes the best way to meet them is to collaborate with them in designing the products they want, without the need for continuous trial and error processes (Jeppesen and Molin, 2003; von Hippel, 1994, 1995, 2005). In this way, it will achieve important savings in such tasks as identifying the needs of the market, the search for relevant information, product design, adaptation of their models to the tastes and preferences of customers, etc. It is, therefore, a valuable strategy if the firm's purpose is to offer differentiated products in less time, with lower costs and possibly, with a higher degree of acceptance from buyers.

Therefore the major contributions of this paper can be summarized as follow. Firstly, we have adopted an original perspective by trying to make operative two variables that usually have been studied from a theoretical point of view, specifically the concept of *sticky* information defined by von Hippel (1994). Secondly, we have confirmed the hypothesis previously tested by Ogawa (1998) about the effects of two kinds of *sticky* information on firms' propensity to cooperate with users, but in a completely different context from the innovation point of view (Spain -a moderate innovator- against Japan -a leading innovator-). Thus, although our data is

related to Spain, it is important to note the generalizability of these findings, particularly to other European countries whose firms have similar patterns of technological cooperation with customers, to those of Spanish firms. Finally, we have been the first, to our knowledge, who have tested the hypothesis about the effects of heterogeneous market needs on firms' propensity to cooperate with users.

Referring to the remaining factors, it is worth pointing out that cooperation with customers is favoured by R&D experience. This backs up the conclusions of previous works (Tether, 2002). This fact can be explained taking into account that as the firm acquires abilities and skills in developing a particular activity, in this case R&D, it is more aware of its internal shortfalls and of the possible benefits that may accrue from the knowledge, abilities and experiences of other agents. In addition, this previous experience also provides the firm with a stock of knowledge that facilitates the acquisition and implementation of new knowledge coming from outside (Cohen and Levinthal, 1990). In this way, cooperation with its customers becomes an important source of extra information, which will facilitate development of R&D activities or help to identify new opportunities which otherwise would go unnoticed.

In a general way, it can be asserted that the more active the firm is in using external information sources, the greater will be the likelihood of its deciding to cooperate with its customers and users. Laurseen and Salter (2004) reached a similar conclusion in their study of cooperation with universities, which leads one to think that it may be the case that firms using "open" strategy methods are more aware of the importance of information provided by external partners.

In this line, we can expect that cooperation with suppliers could be one of the most important engines to foster cooperation with users, because both kinds of cooperation are closely related, as is clearly shown by the fact that, normally, they are studied jointly under the name of "vertical cooperation" (Hauschildt, 1992; Teece, 1992; Tunisini and Zanfei, 1998). It is even possible to foresee that the information provided by different external agents is complementary

and could be valuable for different purposes. Thus, for example, universities contribute to improving the level of basic knowledge (Link and Scott, 2005), whereas the information provided by suppliers may be more geared to incorporating improvements in production processes to remain competitive (Lincoln et. al., 1998; Pérez Pérez and Sánchez, 2002; Pittaway et. al., 2004). The data provided by customers contribute to making new designs more attractive for the market (Henkel and von Hippel, 2004; Jeppesen, 2002, 2005; von Hippel, 2005) and as a result, the time needed for them to be accepted is shortened (Conway, 1993). In all these cases the firm's final aim is to improve its competitive position against its rival. Nevertheless, in cooperating with competitors, the objective is not the same: rather the motivations are more related to setting standards in the market or solving common problems (Tether, 2002).

In similar fashion, the firm's ownership structure has turned out to be an influence on the decision to cooperate with customers and users, confirming the hypothesis that, when part or the whole of ownership is in foreign hands, firms seek collaboration with customers and users of the country to adapt their products and services to local tastes and needs (Tether, 2002).

As far as size is concerned, the results for the case of Spanish firms seem to point along the same line as those who consider that there is not any relationship between size and cooperation (Arora and Gambardella, 1990; Cassiman and Veugelers, 2002; Fontana et. al., 2006; Kaiser, 2002; Kleinknecht and Reijnen, 1992; Motohashi, 2005; Pisano, 1990; Robertson and Gatignon, 1998; Veugelers and Cassiman, 2005;). More specifically, other previous studies using Spanish samples have shown contradictory results. For example, Santamaría and Surroca (2004) or Heijs et. al. (2005) found that a firm's size has a positive influence on the likelihood of vertical cooperation and cooperation with users, while Bayona et. al (2003) and Santamaría et. al. (2002) observed a negative influence of size on firm's propensity to cooperate with users or customers. Other studies, also in the Spanish context, have concluded that size does not exert any influence on firms' propensity to cooperate with external agents (Acosta and Modrego, 2001).

As for the technological intensity of the sector, its lack of influence is surprising, although it is true that a positive relationship can be assumed in the case of high-tech sectors, as indicated by other studies (Bayona *et al.*, 2001, Tether, 2002). However, recently it has been shown that vertical cooperation is not more frequent in high-tech sectors and does not involve firms working on cutting-edge technology (Miotti and Sachwald, 2003), so this can explain the lack of influence of this variable in our study.

In both cases, a more detailed study, which would enable more solid conclusions to be drawn, would be worthwhile.

Among the limitations of the present work is the difficulty of directly measuring the *sticky* information and the degree of heterogeneity of market needs. This could be solved by the design of an ad hoc questionnaire which would include a higher diversity of items related to these variables. Nonetheless, this alternative would mean a loss of data regarding the number of firms taking part in research, so a previous evaluation of the potential advantages of taking this decision should be made. Moreover, the *SBSS* only provides data that is very useful to study the differences in innovatory behaviour between firms that cooperate with users and those that do not cooperate. However, it does not give any additional information about the kind of mechanism these firms are employing to cooperate with users. This is an important restriction, which could be solved if we were able to find a sample of specific firms that were willing to describe the methods they used to cooperate with its users.

In addition, the lack of studies focusing on the concept of *sticky* information gives a good opportunity to complete this work considering, for instance, whether the *stickiness* could vary over time and how this affects the cooperation with users, or if there exist different degrees of *stickiness* which can lead to different levels of cooperation with users. It would also be interesting to carry out this same analysis distinguishing by type of customer, that is to say, differentiating between industrial customers (another firm) or end customers (individuals), as well as contrasting the findings obtained for the Spanish case with those of other countries to

make the results more solid. In addition, it would be useful to analyse the effects of this kind of cooperation on firm's innovation activity.

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FIGURES:

Fig. 1. Manufacturer-Based Design

Manufacturer-based design tasks	**User-Manufacturer Boundary**	**User-based design task**
Have Solution Information Acquire User Need Information from User Combine to Design Responsive Product	←	Have User Need Information

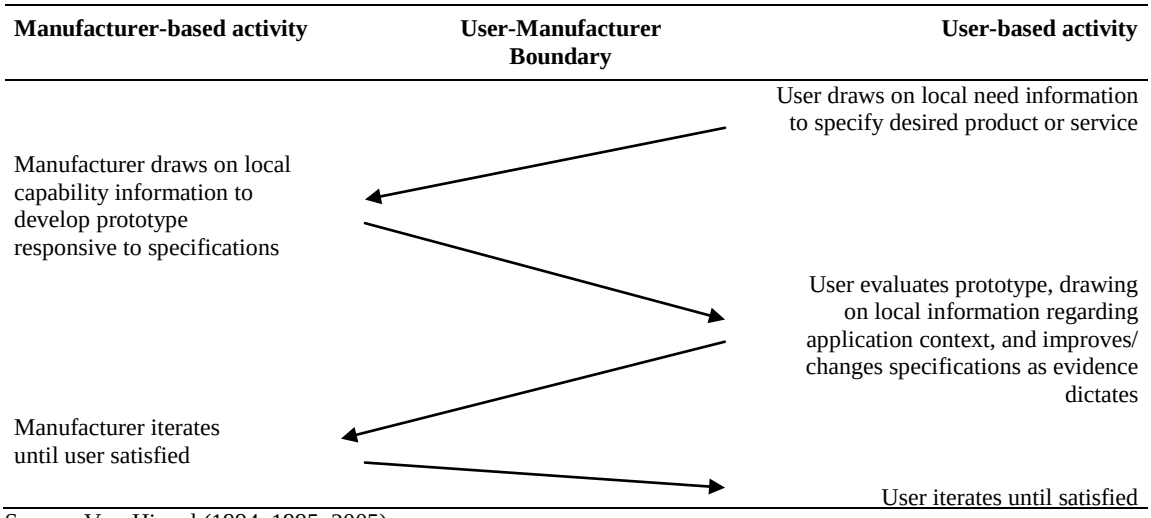
Source: Von Hippel (1995)

Fig. 2. User-Based Design

Manufacturer-based design tasks	**User-Manufacturer Boundary**	**User-based design task**
Have Solution Information	⟶	Have User Need Information Acquire Solution Information from Manufacturer Combine to Design Responsive Product

Source: Von Hippel (1995)

Fig. 3. Iterative Problem-solving Pattern Often Encountered in New Product and Service Development



Source: Von Hippel (1994, 1995, 2005)

TABLES:

Table 1
Characteristics of the sample by size and sectoral R&D intensity

		Size			Sector		
Customer Coop.	**Total**	**Small**	**Medium**	**Large**	**Low-tech**	**Mid-tech**	**High-tech**
NO	1242	701	293	248	901	222	119
YES	291	40	85	166	119	92	80
Total	1533	741	378	414	1020	314	199

Table 2
Descriptive statistics of the chosen variables

Variables	Mean	Std. Dev.	Min	Máx
Cooperation with customers	0.189	0.392	0	1
Information on needs:				
- Market and marketing research [a]	0.934	1.741	0	5
- Product change	0.211	0.408	0	1
Technological information:				
- R&D staff qualification [b]	6.477	16.561	0	100
- Experts and consultants in technologies	0.228	0.420	0	1
Heterogeneous needs:				
- Specific product	0.398	0.490	0	1
R&D experience (t-1)	0.264	0.441	0	1
Openness to cooperation (t-1)	0.710	1.180	0	5
Foreign capital	19.665	38.600	0	100
Size:				
- Small	0.483	0.500	0	1
- Large	0.270	0.444	0	1
Sectorial intensity:				
- Low-tech sector	0.665	0.472	0	1
- High-tech sector	0.130	0.336	0	1

(*) In the case of the dichotomous variables, by simply multiplying their average by 100 we will obtain the frequency of firms meeting these characteristics.
[a] It refers to firms who have carried out or contracted market research for the launching of new products.
[b] It refers to the percentage of staff with higher education qualifications in the total number of R&D department staff.

Table 3
Comparison between firms which cooperate with customers and those that do not cooperate

Variables	Mean (group 1)	Mean (group 2)	Mean diff.	$\chi 2$ [a]	U-Mann Whitney [a]
Explanatory variables					
Information on needs:					
- Market and marketing research [a]	1.656	0.765	0.891	***	
- Product change	0.313	0.187	0.126	***	
Technological information:				***	
- R&D staff qualification	19.393	3.451	15.942		***
- Experts and consultants in technologies	0.515	0.161	0.354		
Heterogeneous needs					
- Specific product	0.515	0.370	0.145	***	
Control variables					
R&D experience (t-1)	0.708	0.159	0.549	***	
Openness to cooperation (t-1)	2.430	0.307	2.123	***	
Foreign capital	42.244	14.375	27.869		***
Size:					
- Small	0.137	0.564	-0.427	***	
- Large	0.570	0.200	0.370	***	
Sectorial intensity:					
- Low-tech sector	0.409	0.725	-0.316	***	
- High-tech sector	0.275	0.096	0.179	***	
N	**291**	**1242**			

*p<0.10, ** p < 0.01
Note: group 1 refers to firms which have cooperated with customers and group 2 to those who have not done so.
[a] For the categorical explanatory variables the chi-squared test has been used and for the continuous explanatory variables the non-parametric U-Mann Whitney due to the heterogeneity of the firms in the sample.

Table 4
Logit analysis of determinants of R&D cooperation with customers

		Logit model		Marginal Effects	
		Coef.	St. Error	dy/dx	St. Error
	Intercept	-3.900***	0.347	-	-
Explicative Variables					
Information on needs	Market and marketing research	-0.106*	0.055	-0.007*	0.004
	Product change	0.438**	0.222	0.035*	0.019
Technological information	R&D staff qualification	0.018***	0.005	0.001***	0.000
	Experts & consultants in technologies	0.520**	0.218	0.0416**	0.020
Heterogeneous needs	Specific product	0.686***	0.217	0.052***	0.018
Control Variables					
R&D experience		0.762***	0.228	0.063***	0.022
Openness to cooperation		1.264***	0.100	0.089***	0.011
Foreign capital		0.010***	0.002	0.001***	0.000
Size	Small	-0.442	0.286	-0.0311	0.020
	Large	-0.202	0.243	-0.014	0.016
Sector	Low-tech sector	-0.244	0.248	-0.018	0.019
	High-tech and mid-high-tech sector	0.335	0.296	0.026	0.026

Number of observations N= 1533
Log Likelihood = -355.0034
Pseudo R^2 = 0.5235
Correctly predicted observations:
Zeroes 92.94%
Ones 77.91%
Correctly classified 90.41%

*p<0.1; **p<0.05; ***p<0.001
In the case of dummy variables, dy/dx represents the discrete change from 0 to 1.
The medium-sized category and the mid-tech sector category have been kept as reference.
[a] Of the total number of firms considered 291 cooperated with customers and 1242 did not.